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The brains of left- and right-handed people have been shown to work slightly differently. Based on performance times, this study illustrates that individuals may process navigational menus differently according to which side (left or right) of the computer screen the menu appears on. Most Web site menus occupy the left of the screen due to convention rather than to the known superiority of the left-sided menu. This study challenges that convention, showing that the right-side menu speeds navigational performance for both left-handed and right-handed users. The right-side menu was also ranked slightly less difficult to use than the left. Despite the fact that participants claimed approximately the same level of comfort using both menus, they still overwhelmingly said they preferred left-side menus. Interestingly, left-handed participants out performed right-handed participants with both menus, even while using mice in their non-dominant hands. Thus, left-side navigational menus do not possess an inherent laterality bias in favor of right-handers, but in fact may slow performance for users regardless of handedness.

Headings:

User Interface Design—Usability

Human Computer Interaction

GIVING NAVIGATION A HAND: LATERALITY AND MENU PLACEMENT

by
Sarah P. Reuning

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Approved by

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Gary Marchionini

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Introduction

This study explores the relationship between two societal trends: left-side Web navigation menus and right-handed mouse users. The majority of Web site navigation menus appear on the left of the screen or on the top and left combined (Nielson, 1999). Indeed, research indicates that most Web users expect to find the navigation menu on the left side of any given Web page (Bernard, 2000). Yet, the prevalence of left-side menus seems to be based more on convention rather than evidence supporting the superiority of left-sided navigation (Nielson, 1999).

Scientists estimate that approximately between 70 and 96 percent of the population is right-handed, or uses the right hand dominantly for such tasks as writing and pitching (Kelly, 1996, p. 9). The left hemisphere of the brain controls the right side of the human body. When one hand is more dominant than the other, the corresponding brain hemisphere is thought to also be more dominant (Towner, 2002). Certain traits have been linked to a specific side of the brain. For example, left-handed people, or people with right-brain dominance, usually demonstrate a "love of creative pastimes, such as music, drama and art, and an aptitude for ball games and sports that require good hand-to-eye co-ordination" (Towner, 2002). Interestingly, there are more left-handed boys in the world than there are girls (Kelly, 1996, p. 9)

Essentially, this study explores the possibility that menu side preference and performance correlate with brain-side dominance, leading to the research question: do right-side navigation menus in hypertext environments enhance the navigation experience of left-handed adults in terms of performance and preference?

Relevant Literature

Laterality

Laterality, or handedness, refers to a person's dominant use of one hand for most tasks. As Towner (2002) explains, "hand dominance is connected with brain dominance on the opposite side. The left hemisphere (right hand) handles the linear thinking mode that controls language, writing, logic, math and science. The right hemisphere (left hand) handles the holistic thinking mode, which controls functions relating to music, art, creativity, fantasy, perception, genius and emotional expression." Studies indicate that left-handed people are "better at spatial awareness and three-dimensional thinking" and they "can adjust better to seeing under water than right-handed people" (Towner, 2002). Furthermore, "lefties may possess superior memory for events" (Minkel, 2001). However, Christman (2001) argues against this notion, stressing that memory performance and brain dominance are unrelated, if brain dominance even exists. "While the notion of people being right-brained or left-brained is common in the popular press," states Christman, "it has received very little support in the scientific literature. Both hemispheres of all people are going to be involved in virtually all tasks" (as cited by APA). Even so, Christman and Propper (2001) found people whose brains' halves work together more actively—i. e., left-handed people, but also right-handed people with left-handedness in their families—remember events better than other people do.

Since some differences in the brain appear to be linked to handedness, it is worth investigating if these differences affect the perception of and subsequent use of left- and right-side justified menus. A correlation may exist between menu side preference and handedness. In addition, user performance using left and right menus may vary depending on the user's handedness.

In the past, attempts have been made to change left-handed people into right-handed people (Kelly, 1996). Like the prevalence of left-sided menus, there is no justification supporting the change to right-handedness other than the fact that the majority of cases fall that way. Unfortunately, as Sattler (1995) has discovered, "converting a person's handedness is equivalent to inflicting grievous harm and results in disability" because "handedness is 'brainedness'" (Sattler, 1995). Additionally, "the damages and injuries that occur as a result of conversion are in part irreversible" (Sattler, 1995). The fact that most computers are equipped with right-handed mice represents an obvious instance of coercing lefties into acting like righties. Does menu placement constitute a similar yet more obscure laterality bias and thus, brain type bias?

Menu Placement

Much has been written regard the types of menus that are most effective in hypertext environments (Hornbæk & Frøkjær [2001], Yu & Roh [2002]); however, very few studies have investigated the placement of menus on the computer screen. Nielson (1999) refers to the overwhelming use of left-justified menus as the "yellow fever" syndrome, noting that this style has permeated Web design without much empirical support. As a result, Harrington (2000) predicts that eventually "all navigation bars will

be on the right side of the screen and not the left" because "most people read from left to right" and "most people are right handed." Harrington cites Nielson (1999) and Fitt's Law in relation to handedness:

> Fit's Law dictates that shorter mouse movements are better: it is always faster to click a target if it is closer to your starting position. Thus, placing the navigation rail next to the scroll bar will usually save users time over placing these two frequently-accessed areas on opposite sides of the window.

Clearly, this aspect of right-side navigation menus only increases usability if the environment in question also contains a scrollbar. Moreover, the advent of mousewheels may negate the Fitt's Law advantage when scrolling is required. Mousewheels are devices built into mice between the right and left mouse button that enable the user to scroll a Web page by simply rolling the wheel forwards or backwards with a finger. This action can be performed at any time regardless of where the cursor is on the computer's screen. Thus, there is no need to move the cursor to a specific area of the screen that supports scrolling, as is the case with the scrollbar. Perhaps this feature explains Chipman, Benderson and Golbeck's (2004) finding that the mousewheel significantly outperforms the scrollbar in the task of locating a specific target on a page. Therefore, as more mice come equipped to support finger-controlled scrolling the distance of navigational menus from the scrollbar on a scrollable Web site may become a non-issue.

Even so, increased usability may result from right-side menus when no scrolling is required. Nielson asserts that users "always look at the content first when they encounter a new web page, so it would be better if the content started at the left border of the window (for users in cultures that read left-to-right). After the users are done with the content, their gaze could naturally shift to the right to decide where to go next. In

contrast, placing the navigation rail to the left requires users to skip over it before they can start scanning the content area" (Nielson, 1999). Nielson argues that right-side navigation menus "might improve the usability of a site by 1%" (1999). However, he also warns that the current trend of placing menus on the left may negate the added usability of right-side menus: "deviating from the standard would almost certainly impose a much bigger cost in terms of confusion and reduced ability to navigate smoothly" (Nielson, 1999). In this vein, Hofer and Zimmermann (2000) examined four different navigational menu positions: top, right, bottom, and left and found that, when used by adults, left-hand navigational menus performed better than all others by a factor of two (as cited in Kalbach & Bosenick [2000]). On the other hand, Kellener et al. (2001) compared left- and right-side lists with corresponding scrollbars and found that no significant difference exists in the usability of each menu type, suggesting users were not disoriented by the location of the menu on the right side.

McCarthy, Sasse, and Riegelsberger (2004) had similar findings when studying peoples reactions via eye tracking to menus located at the top, left and right of the screen. This study found that users "rapidly adapt to an unexpected screen layout" and therefore "designers should not be inhibited in applying design recommendations that violate layout conventions as long as consistency is maintained within a site" (2004). Kalbach and Bosenick (2002) compared two versions of the Audi's Web site, one with left- and one with right-side navigation. Results showed no significant difference in the time taken to complete initial tasks with either menu, though in later tasks, the right-side menu seemed to enhance speed. Furthermore, by tracking eye movement, Kalback and Bosenick discovered that users "tended to focus more on the content side of the page with

a right navigation than with a left navigation" (2002). Finally, when asked about their feelings toward the right-side menu, most users had no opinion. Seven out of 64 users preferred the right-side menu, while only two disliked it. Thus, while some studies indicate no difference in performance and preference between left- and right-justified menus, others find right-side or left-side menus to be slightly better. Significantly, in all of these studies, participants were not divided into left- and right-handed groups.

Laterality and Interface Design

Little research has been conducted studying the relationship of handedness and usability in interface design. Moreover, the majority of existing usability and laterality research focuses on the input of data through various devices without regard to screen layout.

Kabbash, MacKenzie, and Buxton (1993) compared people's performance using input devices in the dominant and non-dominant hand. Participants were asked to perform pointing and dragging tasks using a mouse, a trackball, and a tablet-with-stylus. Results indicate that in manipulating larger objects and/or larger screen areas, both hands performed about the same; however, the dominant hand performs best for precise tasks such as scrolling. Balakrisnan and Patel (1998) proposed use of the PadMouse, a touchpad input device mounted on a mouse base, for facilitating selection and spacial positioning for the non-dominant hand.

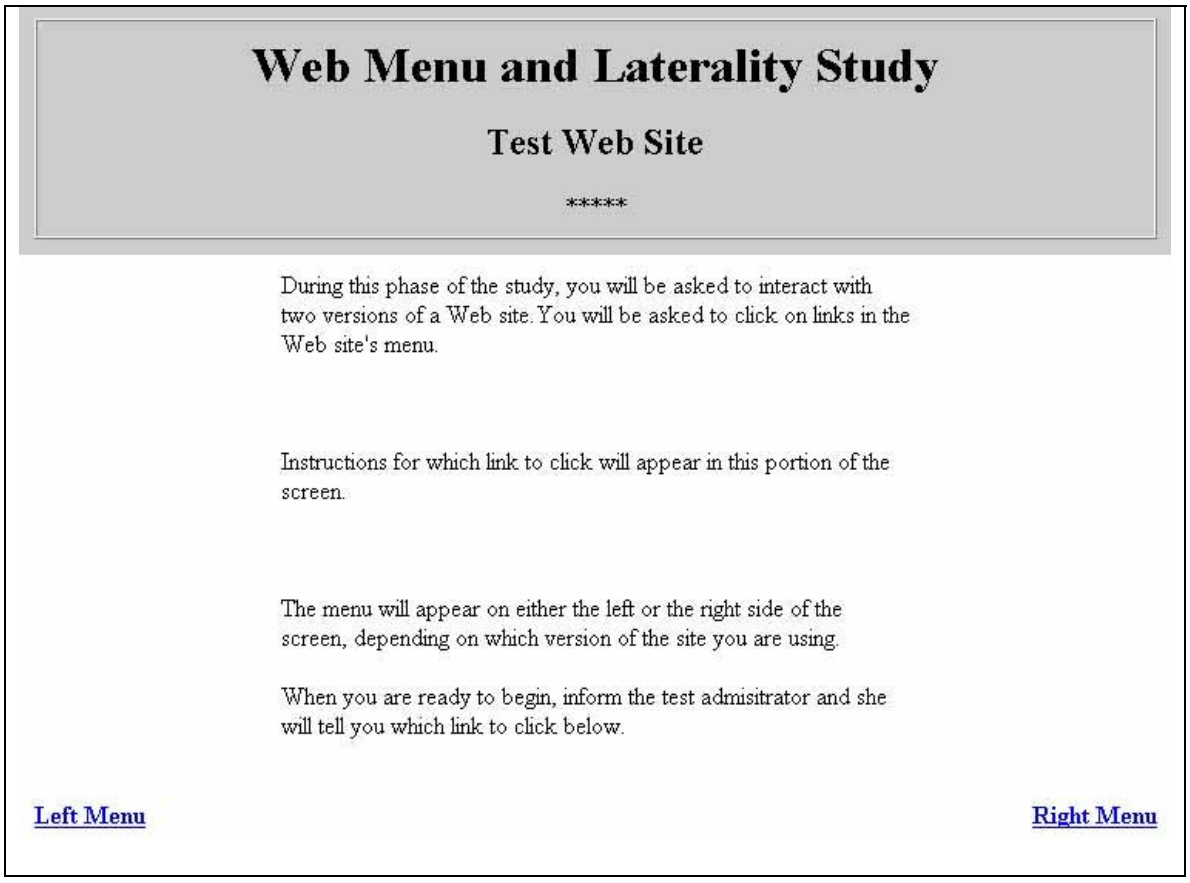
MacKenzie (2001) argues that the current standard computer interface of right-side mouse and keyboard favors left-handed users (assuming left handed users are using left-handed mice). When a system requires both point-and-click input and "power key" input, the system puts undue stress on the right-handed user's dominant hand. Power keys consist of frequently used executive keys, such as ENTER, and modification keys, such as SHIFT. MacKenzie finds five times as many power keys on the right side of the keyboard as on the left. Thus, right-handed users often must choose between releasing the mouse or "reaching over" and typing with the non-dominant hand (MacKenzie, 2001). MacKenzie argues that efforts should be made to couple, or make complementary, the use of hands in interface design.

Myers, Lie and Yang (2000) discuss two-handed input using a Personal Digital Device (PDA) in the non-dominant hand and a mouse in the dominant one. Their research indicates that users have little difficultly entering information into a PDA with their non-dominant hand, as long as there are relatively few buttons to manipulate. As the number of buttons on the PDA increases, the user's performance decreases. Since the typical mouse has few buttons, it is reasonable to assume that the task of using a mouse with the non-dominant hand can be easily mastered with a little practice, as many left-handed people have done. Microsoft research indicates that at least half of lefties use a right-handed mouse (Gordon, 2000).

Web Site and Computer System

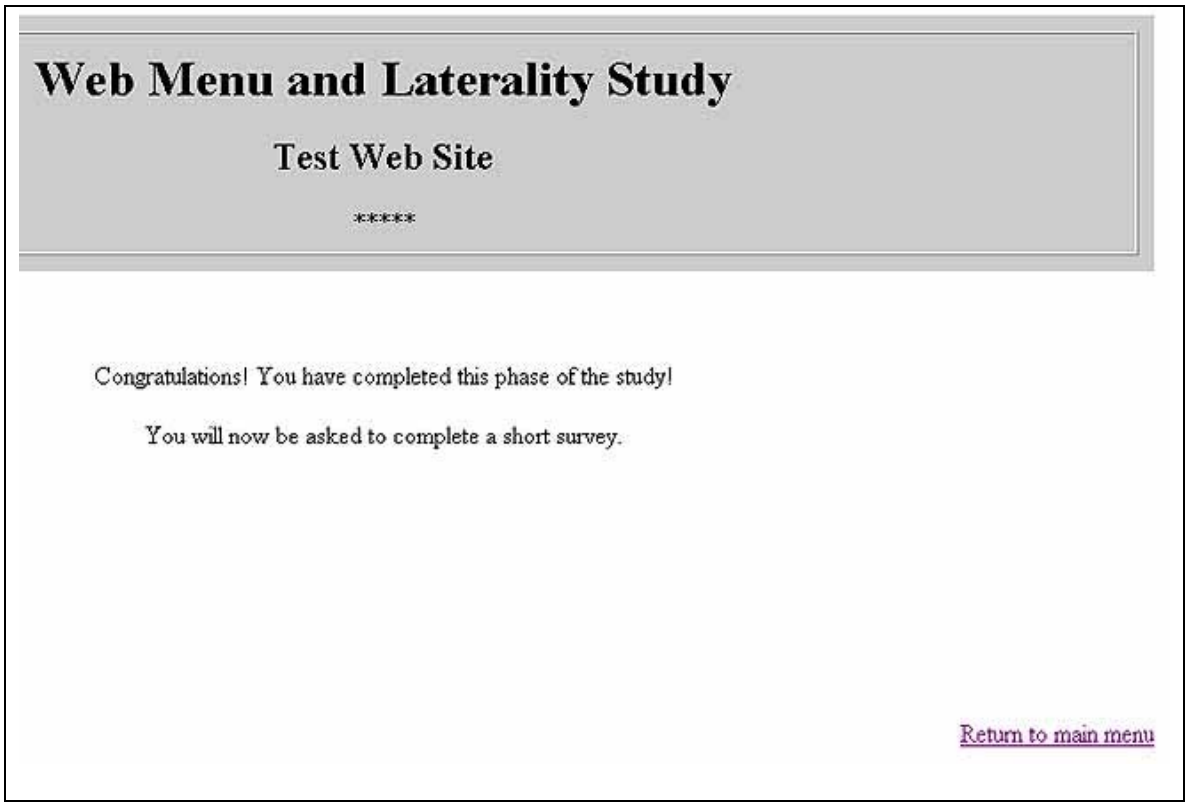
The Web Menu and Laterality Study Test Web Site used during this study was created specifically for the study. The site consisted of a main page containing instructions for using the Web site (see Figure 1) with links to two different versions of the site's content—one version with the navigational menu on the right, and one with the navigational menu on the left. (See Figures 4 and 5 for screenshot examples of the menu placement in the left and right menu versions, respectively.)

Figure 1: Main Page of Laterality Web Site



Instructions for using the site indicated that the user should look at the center portion of each Web page to find the text that revealed which menu link to click next. This content consisted of one to three sentences of text in a 12 point Times New Roman Font, often accompanied by a GIF image ranging from 1 to 3 inches wide. After the correct link was clicked, a new page appeared containing the same menu in the same location, but new page content. This process repeated 14 times for the version of the site with a right-side menu, and 14 for the version with the left-side menu. After clicking through the 14 links on the right menu, the user reached a final page indicating that the test session for that menu location was over (see Figure 2).

Figure 2: Web Page Marking the End of Each Menu Test Session



The same page was delivered after the user had completed the 14 clicks on the left menu. If at any time during the session the user clicked on the wrong link in response to the instructions, the user received the same instructions on the subsequent page along with a message stating, “I’m sorry. That’s not the link we were expecting. Please reread the instructions and choose again.”

Even though the navigational menu’s location changed when participants used each of the two Web site versions, the same navigational menu was used on each version of the site. The link names and order remained constant regardless of whether the menu appeared on the right or left side or the screen. In other words, the menu content and style stayed the same across the two Web site versions.

The navigational menu was composed of 15 one or two word links in a bright blue, 14-point, bold Times New Roman font on a light grey background (see Figure 3). Fifteen as the number of navigational links was chosen for two reasons. First, 15 links in the menu ensured that the participants would have to scroll to click on at least four of the links. Forced scrolling was desirable since the necessity of scrolling coupled with the right-side menu’s proximity to the scrollbar is one of the main reasons right-side menus are thought to be superior to left-side menus (Nielson, 1999). Second, 15 links is well over the “seven plus or minus two” bits of information that the typical user can remember (Miller, 1952). Providing more information than the participants could readily recall helped ensure that users were less likely to memorize the location of menu links after using one version of the site and then greatly improve their time using the second version of the site.

Figure 3: Navigational Menu

As stated above, the study Web site had two versions with the menu on opposite sides of the screen in each version (see Figures 4 and 5).

Figure 4. Sample Page from Left Menu Version of Test Web Site

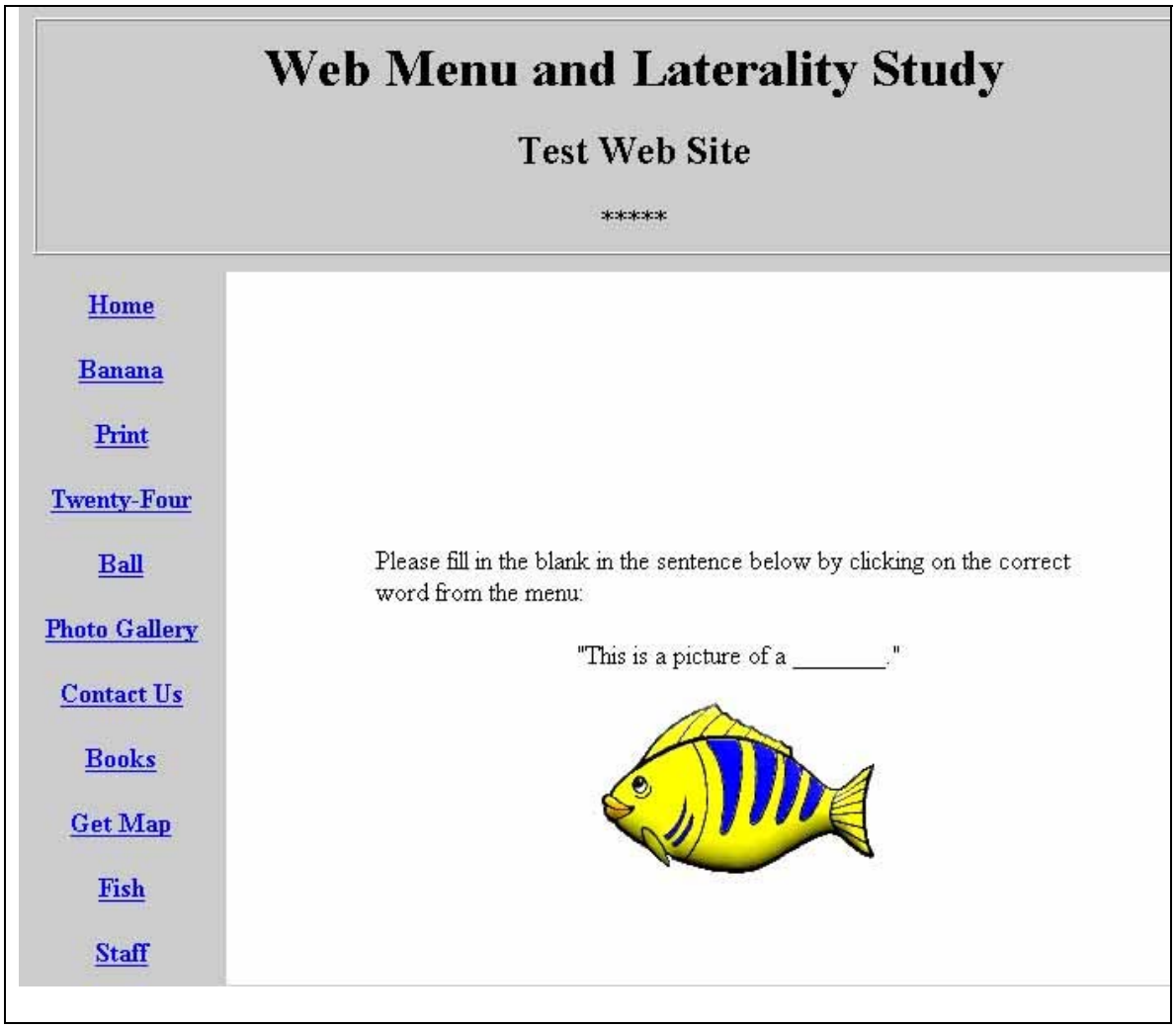
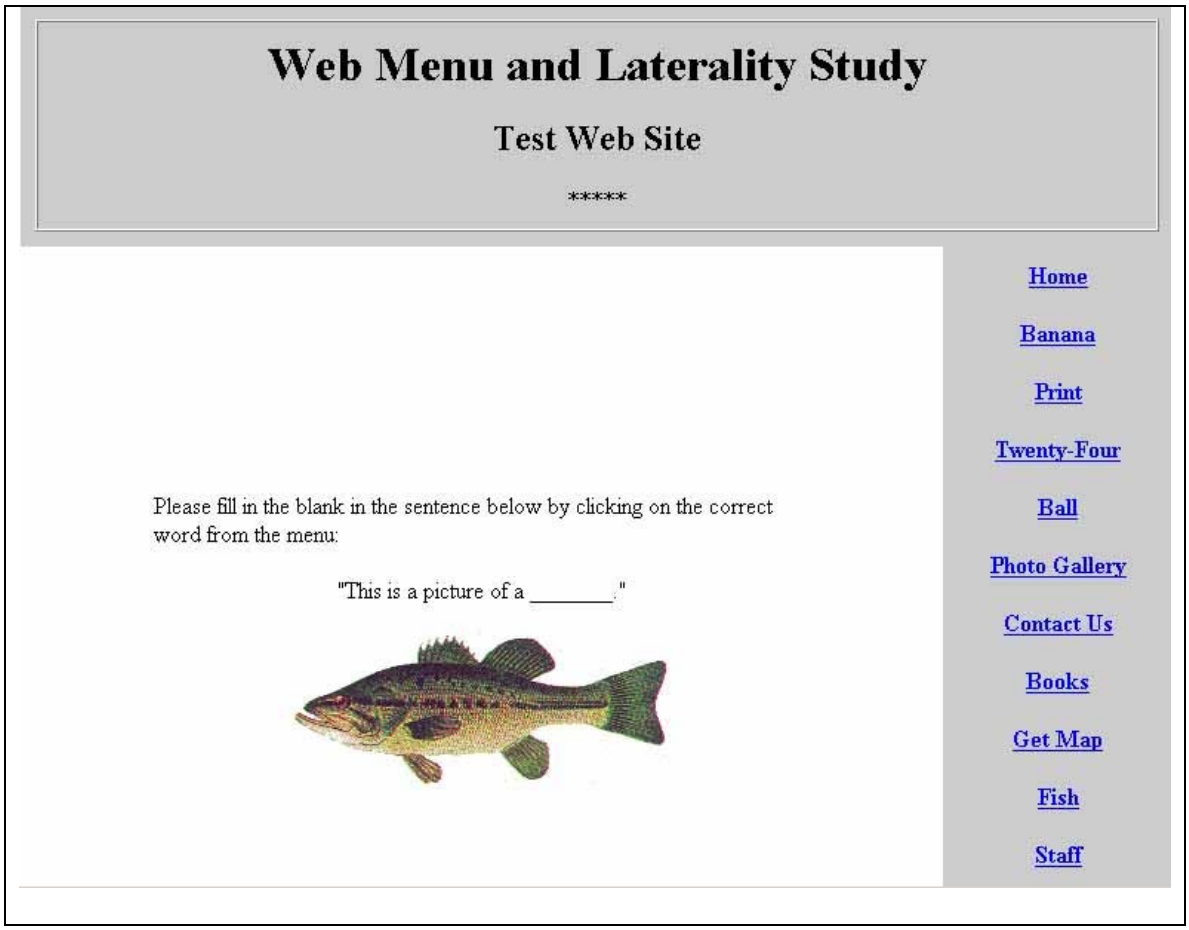


Figure 5. Sample Page from Right Menu Version of Test Web Site



While the menu content remained the same for each version, the instructions for which menu link to click in which order varied, as did the questions asked in the instructions. For example, as seen in Figures 4 and 5, the image of the fish, which was intended to prompt users to click the link labeled Fish, changed between versions. In the right menu version of the site, participants were lead to click on the link "Twenty-four" by the text "Please click on the link that corresponds to the number of hours in one day." In the left menu version, participants were prompted to the same link by the text "If you had $25 and you spent $1, how many dollars would you have left? Please click that link now."

Other page content mirrored situations participants were likely to encounter as Internet users. For example, participants were prompted to click “Print” by pretending to make a hardcopy of the page they were viewing. Other times participants were asked to choose the link they thought would allow them to email the owners of the Web site. (Here the correct answer was “Contact Us.”) Such variation in the content of the Web site versions was included deliberately. Simple variation helped ensure that both site versions maintained the same level of difficulty and contained several realistic tasks while also being diverse enough to make it harder for the users to learn from one testing session to the next and thus, improve their performance on the second version.

Although the content of each site was designed to deter learning, the questions asked of the participants were extremely simple and straightforward, requiring little processing time for the user to determine which link to click next. This design decision helped ensure that the time between mouse clicks more accurately reflected the time spent searching for and then clicking the correct answer to a question (the time spent actually using the menu), rather than reflecting the time spent trying to guess the answer to the question prior to the act of searching for that answer in the menu. Each version of the web site contained approximately the same number of words in the instructions overall, so that reading speed between menu versions should not be considered a significant variable. Additionally, the instructions per page were never longer than three sentences, so that the time taken to read the instructions would not factor greatly into the time spent per page looking for the appropriate link.

As mentioned above, a measure of menu performance on the test Web site could be determined by recording the time between mouse clicks, or the time between one Web page request and the next. The Web server logs for the machine hosting the test site recorded this measure automatically down to the second a page was requested. An example of the logs appears in Figure 6.

Figure 6: Sample of Web Server Logs

Page request dates and times appear in brackets. For security reasons, the accessing computer's IP address has been replaced by Xs while the workstation URL has also been concealed.

```
XXX.XXX.XXX.XXX - - [13/Feb/2004:12:15:30 -0500] "GET /sarah/Right_Menu/right_1.htm
        HTTP/1.1" 200 3099 "http://----------/sarah/" "Mozilla/4.0 (compatible;
        MSIE 6.0; Windows NT 5.1; .NET CLR 1.1.4322)"
XXX.XXX.XXX.XXX - - [13/Feb/2004:12:15:34 -0500] "GET /sarah/Right_Menu/right_2.htm
        HTTP/1.1" 200 3333 "http://----------/sarah/Right_Menu/right_1.htm"
        "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; .NET CLR 1.1.4322)"
XXX.XXX.XXX.XXX - - [13/Feb/2004:12:15:34 -0500] "GET /sarah/Right_Menu/fish.gif
        HTTP/1.1" 200 9368 "http://----------/sarah/Right_Menu/right_2.htm"
        "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; .NET CLR 1.1.4322)"
XXX.XXX.XXX.XXX - - [13/Feb/2004:12:15:40 -0500] "GET /sarah/Right_Menu/right_3.htm
        HTTP/1.1" 200 3301 "http://----------/sarah/Right_Menu/right_2.htm"
        "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; .NET CLR 1.1.4322)"
```

The test Web site was run off of a workstation using Apache 2.0.48 and was the only Web site hosted on this machine during the course of the study. Additionally, this workstation and all of the computers used during test sessions were on a switched 100 Mbps network. Thus, the timestamps in the record of Web page requests was not affected by network delays.

Participants

Fourteen participants were recruited from among individuals subscribed to the SILS (School of Information and Library Science) Student listserv at the University of North Carolina, Chapel Hill. Seven participants were left-handed and seven, right-handed.[1] Seven of the participants were male and seven female, so that four left-handed participants were male and three right-handed participants. The majority of participants were young adults, five, between the ages of 18 and 24, seven between 25 and 30, and only two older than 30. All participants reported using the Internet 5 or more times per week. Thus, participants had significant experience reading text from a computer screen and navigating web sites via the use of links. Significantly, none of the left-handed volunteers regularly used left-handed mice. Two left-handed participants used a touchpad or mouse button located on a laptop keyboard most often when on the Internet, while three right-handed participants used the same kind of embedded laptop input device. Finally, all participants were assumed to speak and read English well, as they were all subscribed to a listserv serving an English speaking community and they were able to read and reply to the study email requesting volunteers.

[1] Prospective participants identified themselves as left- or right-handed when responding to the email advertisement for the study. Handedness was subsequently confirmed in the initial survey by each individual's answer to the question: "Which hand do you write with most often?" Participants who answered "right" were deemed right-handed. The first seven right-handed and left-handed individuals who volunteered for the study were the chosen as participants.

Research Methods

Participants were tested individually during this study. Testing began with the Initial Survey (see Appendix A), gauging Internet and computer skills, handedness, preconceived notions of navigational menus, and what type of mouse the participant normally used. Participants then used one of the two versions of the Web Menu and Laterality Study Test Web Site to perform the task of clicking on specific links within the menu. Participants were randomly assigned to work with either the right-side menu or left-side menu first, so that six of the participants used the right menu site first, while the other eight used the left menu site. Three right-handed people used the right-side menu first, while four left-handed people used the right-sided menu first. Rotating which Web site version was used first was important, since, despite the variation in the Web site versions, participants were still likely to perform better on whichever menu version they encountered second. This testing rotation led to four usage scenarios: 1) left-handed participants using the left-side menu first, 2) left-handed participants using the right-side menu first, 3) right-handed participants using the left-side menu first, and 4) right-handed participants using the right-side menu first.

To interact with the two Web site versions, participants were asked to use one of several uniform Dell Dimension 8100 desktop computers with a right-handed mouse placed on the right side of the keyboard. All mice had a central scroll wheel, which the participants were free to use or not use at their discretion. Prior to and during the study, no mention was made by the researcher of scrolling with or without the mousewheel,

though notes were taken as to whether each participant chose to use the mouse wheel or to click and drag using the more traditional screen scrollbar for each menu. All participants used Internet Explorer 6.2 running on Windows XP to access the Web sites. The monitor resolution during all the tests was set to 1024 by 768 pixels. At this resolution, participants were forced to scroll to see the last four menu options on each version of the Web site. Prior to each test session, the browser's cache of stored Web pages was deleting, ensuring that each page requested from that machine during the test session would result in a request being sent to the Web server and the time of the request being stamped in the server's logs. Participants were given unlimited time to complete the tasks within each Web site version and were asked to determine their own pace while using the Web site.

Following each interaction with a version of the Web site, participants filled out a copy of the Menu Questionnaire (see Appendix B). After filling out the Menu Questionnaire for the second version of the test site, participants filled out the Final Questionnaire (see Appendix C), asking them to compare the experience of using the left and right menus. When this phase was complete, each participant was given $5.00. On average, each test session with each participant took twenty minutes.

Results

In this chapter, the results of the study are presented in two sections: quantitative results and qualitative results. Quantitative results are derived from Web server logs, while qualitative results come from survey responses to the two versions of the Web site.

Quantitative results

For this study, performance was defined as the time elapsed between correct navigational mouse clicks in the system environment. Enhanced performance occurred when using one menu resulted in shorter task completion times than the times achieved using the other menu version. None of the 14 participants clicked an incorrect link during the test sessions, evidencing the simplicity of the required tasks. Since no incorrect links were clicked, the measure of performance became simply the time spent by each participant on each Web page. Time spent per page was determined by recording the time between Web page requests received by the Web server. Thus, the time spent on the first page of the left Web site is equal to the time that the first page of the left menu version was requested subtracted from the time that the second page of the left menu version was requested. The amount of time each participant spent on each page in the left menu and right menu versions of the test Web site appear in Tables 1 and 2, respectively.

Table 1: Time in Seconds Spent Using Left-side Menu by Each Participant
Shaded columns indicate that this version of the Web site was used first by the participant.

	Participant Numbers *Indicates Left-handed Participants													
	1	**2**	**3**	**4**	**5***	**6***	**7***	**8**	**9***	**10***	**11***	**12**	**13***	**14**
Left Menu Total Seconds	157	91	152	98	105	74	105	130	113	146	82	105	117	116

Table 2: Time in Seconds Spent Using Right-side Menu by each Participant
Shaded columns indicate that this version of the Web site was used first by the participant.

	Participant Numbers *Indicates Left-handed Participants													
	1	**2**	**3**	**4**	**5***	**6***	**7***	**8**	**9***	**10***	**11***	**12**	**13***	**14**
Right Menu Total Seconds	113	106	131	123	74	79	92	87	84	154	91	123	86	70

As expected, Tables 1 and 2 show that each participant improved his or her time using the second version of the Web site regardless of whether the second site had the menu on the right or the left. On average, participants spent 119 seconds on the first menu they encountered, while they spent on average 95 second on the second.

Participants seemed to learn from their experiences using one version of the test Web site and were therefore able to perform better using the second version of the site despite efforts of the designer to make the tasks in each version different. Though no two tasks were identical, participants may have learned the location of links within the menu itself, which remained constant. This finding is supported by feedback from one participant's survey that stated, "I would say that both menus were the same level of difficulty to use, but I was less familiar with the options on the menu in the first test, so I hesitated more on that test." Another participant responded that while "it felt a little more natural to use a left-side menu, . . . I was also accustomed to what links I was looking for [while using the left-side Web site version] based on completing the right-side [version] already. Familiarity with a web site helps a lot." Yet another participant described using the second version of the site as "easier because the links were in the same order [as they were on the first version of the site]; this time I expected "Order" to be on the bottom."

From the data in Tables 1 and 2, the following information was derived concerning the four usage scenarios: 1) Left-handed participants using the left-side menu first, 2) left-handed participants using the right-side menu first, 3) Right-handed participants using the left-side menu first, and 4) Right-handed participants using the right-side menu first. This information is summarized in Table 3.

Table 3: Average Participant Time Spent Using Each Menu According to the Four Usage Scenarios

	Average Participant Time Spent (in Seconds) . . .			
	on Left menu version when left-menu was used first	on Left menu version when right-menu was used first	on Right menu version when right-menu was used first	on Right menu version when left-menu was used first
Right-handed Participants	139	98	117	100
Left-handed Participants	110	101	108	84

As shown in Table 3, Left-handed participants who used the left-side menu first performed more quickly by an average of 29 seconds when using the left-side menu, than did right-handed participants using the left-side menu who also used this menu version first. Right-handed participants were 9 seconds slower on average using the right-side menu when the right-side menu was used first, than were their left-handed counterparts under the same circumstances. Right-handed participants were on average 16 seconds slower using the right-side menu when that menu was used second than were left-handed participants. Left-handed participants who used the right-side menu first performed on average 3 seconds slower with the right-side menu, than did the right-handed participants who used the same menu first. This final scenario proved the only scenario in which right-handed participants outperformed left-handed participants. Interestingly, left-handed participants out performed right-handed participants 75 percent of the time, even while using their non-dominant hand to control the mouse.

The data in Table 3 also addresses the main research question of this study—did the left-handed participants perform better with the right-side menu? In fact, both left-handed and right-handed participants performed faster on average using the right-side menu, a statistic gained by adding the time spent by all participants on each menu according to handedness and dividing that number by two. Left-handed participants spent an average of 106 seconds on the left menu Web site version, while they spent 96 seconds using the right menu version. Right-handed individuals spent an average of 119 seconds on the left menu Web site version and 109 on the right menu version.

While lefties did perform an average of 10 seconds faster using the right menu, this finding does not support the hypothesis that left-side Web menus are biased in favor of right-handed users. Righties also performed an average of 10 seconds faster using the right-side menu. Interestingly, the left-handed participants in this study out performed the right-handed participants by an average of 13 seconds using the right-side menu.

One variable deemed likely to affect performance was whether participants chose to use the mousewheel or the scrollbar for scrolling down the menus. Table 4 compares the type of scroll mechanism used to times spent on each menu:

Table 4: Scroll Mechanism and Time

Shaded cells indicate that the site version referred to by that cell was the first version used during testing. Times listed in bold, italic text were achieved using the mousewheel.

	Participant Numbers *Indicates Left-handed Participants													
	1	**2**	**3**	**4**	**5***	**6***	**7***	**8**	**9***	**10***	**11***	**12**	**13***	**14**
Total Seconds Using Right Menu	113	106	131	123	***74***	79	92	***87***	84	154	91	***123***	***86***	70
Total Seconds Using Left Menu	157	***91***	152	***98***	***105***	74	105	***130***	113	146	82	***105***	***117***	116

From Table 4 the following conclusions can be drawn. Two left-handed and two right-handed people used the mousewheel with both the left and right menus. Two righties used the mousewheel only in conjunction with the left menu. Participants who used the mousewheel to scroll the left-side menu spent and average of 108 seconds on this site, while those who did not, spent 118 seconds on the same site. When using the scroll button with the right-side menu, participants spent an average of 93 seconds on that site. Participants who did not use the mousewheel on the right menu navigated the same site in an average of 104 seconds. So, using a mousewheel did speed navigation of the scrollable menus when compared to using a scrollbar—a finding anticipated by Fitt's

law. However, using the right-side menu still proved quicker (by an average of 15 seconds) than using the left side menu when the mousewheel was used with both. Of course, these data are based on a small number of mousewheel users, so they must be interpreted with caution.

Qualitative Results

In general, participants were able to find the appropriate links more quickly using the right-side menu than the left-side menu. However, did participants also prefer the right-side menu? Did they find it easier to use? For this study preference was determined by asking participants their preferences via surveys.

Entering the study, 10 of the participants reported that they expected to find the navigational menu on the left-side of any given Web site, while the remaining four expected the menu at the top of the screen. Results from the Menu Questionnaires filled out directly after interacting with each menu reflect this left-side mentality, revealing that participants overwhelmingly said they preferred the left-side menu to the right. After using the left-side menu, all participants answered that if given a choice between having the menu on the left or the right, they prefer the menu on the left. When asked the same question following use of the right-side menu, only four of the fourteen participants favored the right menu. Notably, although most participants reported that they preferred the left-side menu to the right-side menu, the right menu was considered, on average, easier to use then the left. On a scale of 1 to 5, with 1 being very easy and 5 being very hard, the right-side menu received and average score of 1.7, while the left-side menu received a score of 1.9. It seems that although the right-side menu was not more difficult

to use than the left, participants preferred the familiar left-side layout. As, one participant explained after using the left-side menu, "I prefer the menu on the left side because that is where I expect to see the menu, it makes more visual sense to me, but using the right side menu was not more difficult."

Participants were asked how they liked the placement of the menu on each of the Web site versions and were given the choices: "liked it a lot," "liked it somewhat," "neither liked nor disliked it," "disliked it somewhat" and "disliked it a lot." By this measure, participants did like the left menu somewhat better than the right overall. None of the study volunteers disliked either menu a lot. These survey results are broken down in Table 5:

Table 5: Participant Likes and Dislikes Using Left- and Right-side Menus
Numbers represent the number of participants who chose a specific feeling according to menu used.

	Left-side Menu	**Right-side Menu**
Liked it a lot	4	1
Liked it somewhat	6	8
Neither like it nor disliked	1	2
Disliked it somewhat	3	3
Disliked it a lot	0	0

Participants were also asked to gauge their level of relaxation or tension while using each menu. Results from this section of the Menu Surveys appear in Table 6.

Table 6: Participant State of Mind while Using Left- and Right-side Menus
Numbers represent the number of participants who chose a specific state according to menu used.

	Left-side Menu	**Right-side Menu**
Relaxed	5	5
Somewhat Relaxed	5	6
Neither Relaxed nor Tense	3	2
Somewhat Tense	1	1
Tense	0	0

As shown above, participants felt no more tense using the right-side menu than they did using the left. Additionally, if one combines the scores for "Relaxed" and "Somewhat Relaxed," as a representative number for a positive state of mind, the right-side menu actually scores marginally higher.

Results from the Final Survey were mixed, but still generally favored the left menu over the right. Five participants preferred the left menu, while four preferred the right. The remaining five participants claimed to have no preference. When asked if they found one menu more difficult to use than the other, three participants (two right-handed) reported the left menu more difficult to use, while three others (two right-handed) declared the right menu harder. The remaining eight participants found the menus equally difficult. Participants who found one menu harder to use than the other were asked to explain why. Their reasons are shown below in Table 7:

Table 7: Participant Reasons Why One Menu Location Was Easier to Use

Left-side menu was easier because . . .	**Right-side menu was easier because . . .**
The right side seemed to be more difficult to read and find the info. The left side was better once I took advantage of the scroll function on the mouse.	Right menu was closer to my hand. The cursor was interfering with the text when I had to move it to the left menu.
The left menu probably only felt preferable because I am used to it being situated in this portion of the screen. Then again, maybe my eyes would travel left initially, regardless, because I am used to reading left to right.	The proximity of the right-hand menu to my mouse—my eyes to my hand—could explain why the right-hand menu was easier to use. I'm speculating of course, but perhaps the left menu was harder because of the extra distance.
I'm used to reading left to right so it seems easier to start on the left when I want to find something	Left-side seemed easier to read at first, but it [the left menu] was more difficult to use due to the need for scrolling. However, once I started to use the scroll option on the mouse I did not need to more over the page with the cursor.

Conclusion

This study proves significant by expanding human-computer interaction and usability research into areas previously uncharted. Heretofore, very little research has been conducted on the effects of laterality and interface design—none of which explores menu placement. A few studies investigate the differences between right- and left-justified menus, yet none of the previously mentioned studies considers how laterality may affect performance and preference for right- and left-side menus.

This study investigated whether right-side navigation menus in hypertext environments enhance the navigation experience of left-handed adults in terms of performance and preference. Based on evidence gathered from Web server logs, it appears that right-side navigation menus do enhance performance for both left- and right-handed users. Fitt's law suggested this outcome for a scrollable Web site, assuming users would need to navigate the cursor a greater distance from the left-side menu to the scrollbar than from the right-side menu to the scroll bar. However, some participants in this study chose to use a mousewheel rather than the scroll bar. These participants, as anticipated by Fitt's Law, did out perform the participants who used the traditional scroll bar since less cursor movement was required with the wheel. Yet, when participant times using a mousewheel with the left-side menu were compared to participant times using the mousewheel with the right-side menu, the right-side menu proved faster to navigate. Fitt's law cannot account for this time differential.

Perhaps the right-side menu proved quicker to use because the English language reads left to right, as Nielson (1999) notes. Theoretically, when participants finished reading the Web site text in the center of the page telling them which menu link to click, their eyes were focused on the right side of the screen. Thus, after reading the page content on the right-side menu version of the site, the participant's eye would be ready to read the menu links that followed, whereas, after reading the page content on the left-side menu version of the site, the eye would be forced to skip back over the text it had just read to find the links in the left menu. Essentially, this theory proposes an eye movement equivalent to Fitt's Law to explain why the right-side menu out performs the left-side menu when the mousewheel is used.

While these findings about right-side menu performance prove valuable, this study set out to examine possible links between menu location, performance, and laterality. Surprisingly, left-handed participants in this study out-performed right-handed participants by an average of 10 seconds with each of the two menu locations, a finding that does not correlate to gender, age, or other variables recorded in this study. If user performance with both left- and right-side menus varies depending on the user's handedness—as this research suggests—then perhaps this tendency can be explained by enhanced memory of lefties for certain events, such as navigating a Web site. Of course another explanation is that the findings are simply due to chance and the relatively small number of test subjects.

While users demonstrated a clear difference of performance on each of the two Web site versions, user preference did not mirror this finding. Despite the fact that users performed faster with the right-side menu, they still claimed (when asked to chose

between the right and left as menu locations) that they preferred the menu be located on the left side of the computer screen. Ironically, another indicator of user preference—how well participants liked the location of the menu in each of the two Web site versions—revealed that the two locations received very similar scores. Participants also claimed to have approximately the same level of mental comfort using menus in each of the locations.

Clearly, users' preconceived notions of where a menu should be affected their responses, so that even though both menus were ranked nearly the same in terms of difficulty, the left menu was still greatly preferred. One participant recognized his or her expectations prior to using the right-side menu, stating: "I was surprised at how much I liked the right-hand menu. I'm so accustomed to the left-hand side menus that I expected to be disoriented. To the contrary, it was great!" Yet, despite this one observation, the majority of the participant preferences for menu location matched participant expectations for menu location. In other words, the majority of people expected the menu to be on the left side and given a choice, said they preferred the menu there.

According to the study results, no correlation exists between menu side preference and handedness. Furthermore, the convention of using left-justified menus and right-handed mice does not seem to constitute a bias toward right-handed learners, as lefties out-preformed righties using the left-side menu.

It is worth noting that while none of the survey questions in this study referenced scrolling, many participants complained about the necessity of scrolling the menus in each Web site version. As one participant stated "it was annoying to have to scroll down for links." Another participant "wanted to be able to see the entire menu without moving the mouse." Still another participant linked his or her frustration with scrolling to memory, recalling Miller's (1954) magical number seven:

> I find that with my poor short-term memory, I had to scroll down a couple more times than I would have liked in order to see all the options on the menu. I'd prefer to be able to see all the menu options without scrolling.

These findings support the general usability guideline rejecting forced scrolling, as well as supporting Miller's finding that human memory works best with no more than seven (plus or minus two) bit of information.

Another complaint gleaned from the surveys was the lack of ordering among the menu links. One participant suggested that an alphabetized list would be more "intuitive." While another stated that the menu, regardless of location, was difficult to use because links like "Contact Us" did not appear where the user expected them to, based on experience with other Web site menus. This participant claimed to have taken more time with the menu because he or she often "jumped to a position where [he or she] though the correct link would or should be in the menu" and the link was not there. These comments suggest that Web designers should strongly consider any layout precedents when creating menus.

Areas of Further Study

In the past, educators have overtly tried to change "lefties" into "righties," much

to the detriment of left-handed individuals (Kelly, 1996). Yet, the results of this study suggest that being left-handed is favorable in that it enables one to navigate Web sites more quickly. Subsequent studies should be conducted to test this theory. If this finding proves reproducible, then researchers should ask what enables left-handed people to better navigate hypertext environments. The answer to this question may benefit society by shedding light on how the brain processes information.

Additionally, researchers should examine whether right-side justified menus really do enhance navigation time over left-side menus when scrolling is conducted via mousewheel. Eye tracking studies may reveal if right-side menus are superior only when used on sites in languages that are read left to right. Hopefully, the results of this study will encourage more research that explores the connections between laterality and good Web interface design. At a minimum, these results may benefit society by furthering scientific knowledge about user preferences and performance using right- and left-side justified navigation menus.

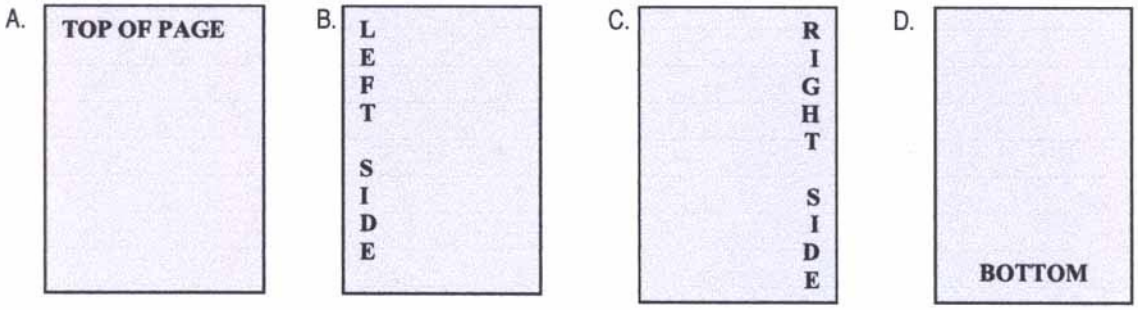
Appendix A: Initial Questionnaire

Participant Number _____

Please circle the answer that best applies to you.

1. How often do you use the Internet per week?
   A. never use (skip to question 3)
   B. 1-3 times
   C. 3-5 times
   D. 5 or more times

2. When you think of a typical Web page, where on that page do you expect to find the navigational menu (the main menu that frequently includes such buttons as “Home,” or “About Us”)?



3. When you use a computer, what type of mouse do you use most often?

   A. Don’t use a computer, or don’t use a computer with a mouse
   B. Right-handed mouse (separate from keyboard)
   C. Left-handed mouse (separate from keyboard)
   D. Touch screen or mouse button built into the keyboard of a laptop

4. Which hand do you write with most often?
   A. Right
   B. Left
   C. Neither, write with both hands equally often

4. What age group best describes you?

   A. 18-24
   B. 25-30
   C. over 30

5. Which gender best describes you?

   A. Male
   B. Female

Appendix B: Menu Questionnaire

Participant Number _____

Please circle the best answer or write in the area provided.

1. For the site you just used, which side of the screen was the menu on?

A. Right
B. Left
C. Don't know

2. On a scale of 1 to 5, with 1 being very easy and 5 being very hard, how hard was it to use this site?_____

3. How did you like the placement of the menu on this site?

A. Liked it a lot
B. Liked it somewhat.
C. Neither liked nor disliked it
D. Disliked it somewhat
E. Disliked it a lot

4. Given the choice between having a menu on the left or the right side of your screen, which side do you prefer?

A. Right
B. Left

4. Which word best describes your state of mind while using this site?

A. Relaxed
B. Somewhat relaxed
C. Neither relaxed nor tense
D. Somewhat tense
E. Tense

5. In your own words, how would you describe the experience of using this site?

_____

_____

_____

Appendix C: Final Questionnaire

Please circle your answers.

Participant Number _____

1. Did you prefer one menu location to the other?
   A. Yes, right-side menu
   B. Yes, left-side menu
   C. No, no preference

2. Was one menu harder to use than the other?

   A. Yes, the right-side menu was harder to use than the left-side menu
   B. Yes, the left-side menu was harder to use than the right-side menu
   C. No, both menus were about the same

3. If you answered A or B to the question above, please write a few words about why you think one menu was harder to use than the other:

_____

_____

_____

_____

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